Analysis of Pedestal Values in LArIAT

Derek Walker, Louisiana State University – SULI Program
Jen Raaf, Fermilab

Background

Neutrinos are neutral particles that interact only through the weak force and come in three types: the electron flavor, muon flavor, and tau flavor. The discovery of neutrino oscillations [1] [2] and the corresponding fact that neutrinos have mass, has pushed neutrinos to forefront of beyond the standard model physics research. In recent years, the leading candidate for detecting neutrinos has been liquid argon in a time projection chamber (TPC).

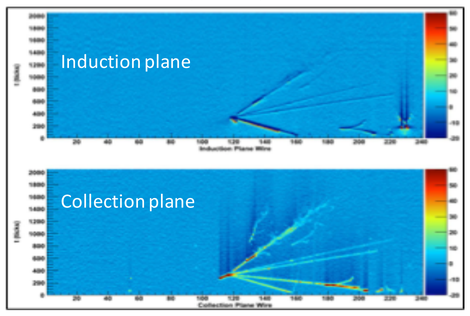

Figure 1: Shows a candidate neutrino event from ArgoNeuT, a small liquid argon TPC. http://t962.fnal.gov/Images.html

LArIAT

LArIAT, LArTPC in a test beam, is an R&D LArTPC meant to characterize how various particles, muons, kaons, pions, protons, and electrons, interact in liquid argon [3]. In order to properly measure these interactions, this project seeks to characterize the pedestal values, the minimal electrical noise on the wire planes, in LArIAT in order to look for possible sources of error when reconstructing particle tracks.

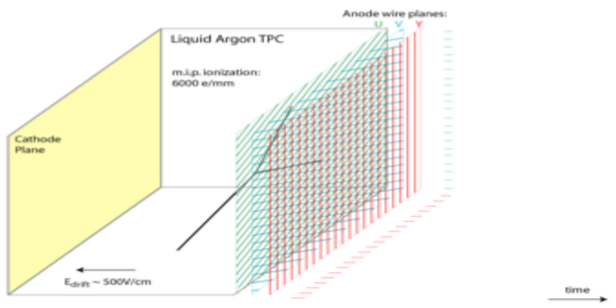

Figure 2: The figure above gives a schematic overview of how a TPC works. As an ionizing particle comes in and deposits charge, that charge is collected on the wire planes, which act as a coordinate chart. The particle's path can then be reconstructed. Image Credit: B. Yu

Methodology

LArIAT has two wire planes each containing 240 wires. Wires 0–239 make up the induction plane and wires 240–479 make up the collection plane. The pedestal values were obtained using at most the first eight events of each sub-run, one minute of data taking, that were purposefully left empty to examine pedestal values. LArSoft, LArIATSoft, and ROOT were used to do the analysis.

Results

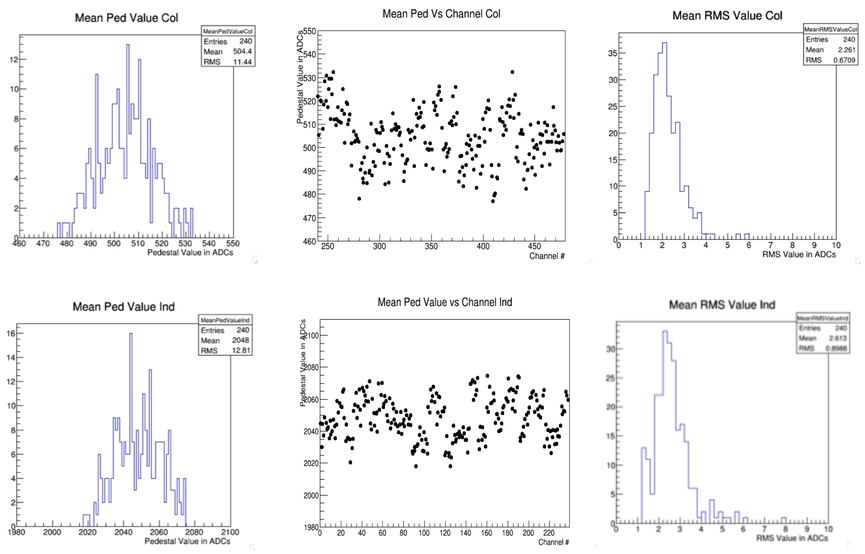

Figure 3: In both rows (Top: collection plane; Bottom: induction plane), the left plot is a 1-D histogram displaying the distribution of pedestal values for all wires in the given plane. The middle histogram shows this value plotted against channel number. (Channel number equals wire number.) The right plots are 1-D histograms of the RMS values for each wire.

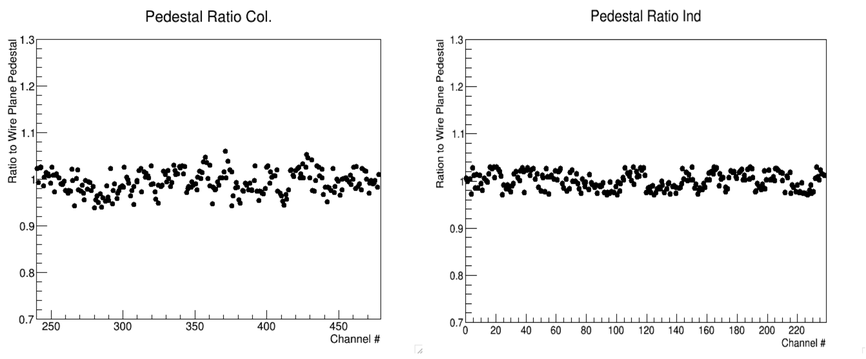

Figure 4: The plots above are made by finding the average pedestal value for the entire plane (collection plane on the left, induction on the right), then finding the ratio of each individual wire's pedestal value to plane's average value

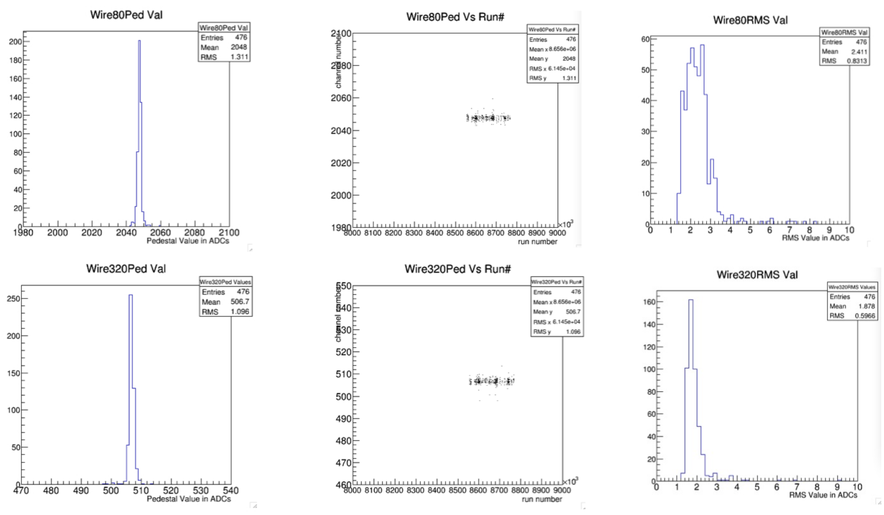

Figure 5: The plots above are two wires, one from the collection plane and one from the induction plane, with each row being a different wire. The middle plots in each row show the pedestal value vs. run number, essentially pedestal value vs. time. The left plots are the middle one projected onto the y-axis to show the spread of the pedestal values over the wire. The RMS of the pedestal values for the individual wire, accumulated over all sub-runs, are plotted in the figures on the right.

Conclusion

The results clearly show that the pedestal values are relatively stable over time and thus do not appear to have a significant effect on the efficiency of track reconstruction in LArIAT. The right plots in Figure 3 show how relatively small the RMS is in the wire planes. As a percentage of the pedestal values, the fluctuations are roughly two percent for the collection plane and half a percent for the induction planes. The left and middle plots in Figure 5 confirm this by showing how the pedestal values are relatively uniform over time. Now there is a distinction to be made. There is fluctuation in the average pedestal value from wire to wire, but as long as each individual wire is constant over time, then it will not affect reconstruction.

Future Plans

This project has two future goals that it wants to pursue. The first is to automate the analysis that was done so that it will constantly be updated when the detector is running. Another avenue that looks fruitful to pursue is to examine how the pedestal values, and especially the RMS of those values, change when the TPC is being filled with liquid argon.

References

1. Y. Fukuda et al., PRL 81 1562 (1998).
2. Q. R. Ahmad et al., *Phys. Rev. Lett.* 87, 071301 (2001).
3. F. Cavanna et al., [LArIAT Col.] arXiv:1406.5560 [physics.ins-det], 2014.

Acknowledgments

I would like to give a huge thanks to my mentor, Jen Raaf, who was there to help me with every step of this project. A special thanks to Jason St. John, Dan Smith, and all the LArIAT collaborators who helped answer my many questions. Thank you to LArIAT, a little detector with a big heart. Finally, I would like to thank the U.S. Department of Energy for providing me the necessary funding and resources to carry out this project.

Fermilab
U.S. DEPARTMENT OF ENERGY | Office of Science